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16. Abstract

This is a compilation of material that was presented at the Third UMTA R&D Priorities Conference Workshops on Rail and Construction Technology. Part I deals with railcars and equipment, and includes discussions of the rail technology R&D program, the rail system studies of the Congressional Office of Technology Assessment, and the problems connected with technology deployment. Part II, construction technologies, includes discussions of construction technologies and costs and the transit industry's views of UMTA's R&D program in this area. This volume contains five resource papers which can be found summarized in Volume I of this report along with summaries of other workshop sessions. Volume I also includes the proceedings of the general sessions and a listing of conference participants.

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PREFACE

This report contains proceedings of workshop sessions of the Third Urban Mass Transportation Administration R&D Priorities Conference which was held at the U. S. Department of Transportation's Transportation Systems Center in Cambridge, Massachusetts, November 16 and 17, 1978. This volume contains the following:

Rail and Construction Technology Workshops

Part I : Railcars and Equipment
Part II: Construction Technologies

These conferences are sponsored periodically by UMTA to enable them to communicate directly with those who represent the views of transit users, operators of public transportation systems, suppliers of equipment and services, the research community, and governments at the State, local, and Federal levels. The purpose of the Third Conference was to provide a current review of UMTA's research and development plans and to solicit recommendations for improving the direction and effectiveness of its program. The conference included general sessions on research and development policy and a total of fifteen half-day workshops on research, development, and demonstrations in urban transportation systems, technologies, planning, management, and services.

The volume containing proceedings of the general sessions and summarized reports of the workshops has been published by the Urban Mass Transportation Administration. However, because of the volume of papers, presentations, and discussions, detailed proceedings of the workshops have been compiled into separate reports by subject area. All of these documents are available from:

National Technical Information Service
U. S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161

When ordering copies of these reports from NTIS, please refer to the list of reports numbers and titles which follows.

1. Third UMTA R&D Priorities Conference, November 1978, Volume I: Proceedings of General Sessions and Summarized Reports of Workshops, DC-06-0157-79-1.

2. Third UMTA R&D Priorities Conference, November 1978, Volume II: Proceedings of Bus and Paratransit Technology Workshops, DC-06-0157-79-2.

   Part I : Paratransit Integration
   Part II: Bus Technology, Paratransit Vehicle Development, Flywheel Energy Storage System

3. Third UMTA R&D Priorities Conference, November 1978, Volume III: Proceedings of AGT and Advanced Systems Workshops, DC-06-0157-79-3.

   Part I : AGT Socio-Economic Research and AGT Applications
   Part II: AGT and Advanced Systems and Technologies

4. Third UMTA R&D Priorities Conference, November 1978, Volume IV: Proceedings of Service and Methods Demonstrations Workshops, DC-06-0157-79-4.

   Part I : Pricing Policy Innovations
   Part II: Conventional Transit and Paratransit Service Innovations

5. Third UMTA R&D Priorities Conference, November 1978, Volume V: Proceedings of UMTA Special Technology Programs Workshops, DC-06-0157-79-5.

   Part I : Safety, Qualification, and Life-Cycle Costing
   Part II: Consumer Inquiry Technology, National Cooperative Transit R&D Program, and Technology Sharing

6. Third UMTA R&D Priorities Conference, November 1978, Volume VI: Proceedings of Rail and Construction Technology Workshops, DC-06-0157-79-6.

   Part I : Railcars and Equipment
   Part II: Construction Technologies

7. Third UMTA R&D Priorities Conference, November 1978, Volume VII: Proceedings of Transit Management Workshops, DC-06-0157-79-7.

   Part I : Management Systems Developments
   Part II: Human Resources Development

8. Third UMTA R&D Priorities Conference, November 1978, Volume VIII: Proceedings of the Access for Elderly and Handicapped Persons Workshops, DC-06-0157-79-8.

   Part I : Planning and Regulation
   Part II: Demonstrations and Hardware

9. Third UMTA R&D Priorities Conference, November 1978, Volume IX: Proceedings of the Urban Transportation Planning Workshop, DC-06-0157-79-9.

RAIL AND CONSTRUCTION TECHNOLOGY I

Chairperson: *Stewart B. Hobbs*, Director, Office of Ground Systems, Transportation Systems Center

UMTA'S RAIL AND CONSTRUCTION TECHNOLOGY PROGRAM: RAILCARS AND EQUIPMENT, POWER, SIGNALS, AND COMMUNICATIONS: *Stephen S. Teel*, Acting Director, Office of Rail and Construction Technology, UMTA

OFFICE OF TECHNOLOGY ASSESSMENT'S PERSPECTIVE: *Robert L. Maxwell*, Transportation Group Manager, U. S. Congress Office of Technology Assessment

Panel: *David Gunn*, Director of Operations, Massachusetts Bay Transportation Authority, Boston

Kenneth Fraelich, Sales Manager, Westinghouse Electric Corporation.

Deane N. Aboudara, Director, Department of Technical and Research Services, American Public Transit Association

Thomas O'Brien, Boeing Vertol Company

Albert Dzingelis, Senior Electrical Engineer, New York City Transit Authority

REPORTER: *Robert J. O'Connor*, Transit Systems Branch, Transportation Systems Center

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RAIL AND CONSTRUCTION TECHNOLOGY I

An initial program plan has been developed to provide a R&D program which is responsive to urban transit needs of the next decade. An initial urban rail system market analysis was prepared which identified opportunity areas for urban rail R&D in ways, facilities, and structures; vehicles; and operations and maintenance. In addition, the program included studies of processes for minimization of life-cycle cost and development of maintenance management procedures for LRT operations.

The analyses conducted under this program will provide a basis for identifying and selecting R&D projects. The methodology for prioritizing R&D funding will be a function of three factors:

1. Program funds will be a function the size of the market affected by the R&D. Market projections will be translated to a uniform annual equivalent level of future expenditures taking into account the period in which a particular technology could be made available.

2. Program funds will be proportional to the relative effectiveness of the proposed projects. Both quantitative and qualitative aspects will be considered in developing effectiveness measures. Life-cycle costs will be considered as a quantitative measure of potential effectiveness along with qualitative measures such as performance, safety or accessibility.

3. Program funds will depend on the phase of the R&D cycle that a proposed technology program falls in. This refers to the need to continually evaluate and justify programs at each state of the R&D process on the basis of expected benefits.

In reviewing the history of the UMTA Section 3 modernization program, it is apparent that the greatest market area by far was rolling stock followed by rights-of-way and stations/terminals. These relative rankings, based on a recent study entitled "The UMTA Rail Modernization Program," are influenced by the replacement of a major portion of the commuter car fleet during the last decade. The UMTA R&D budget prior to 1978 was heavily weighted toward improvements in the rolling stock area. Using market size as a measure by itself it appears that earlier R&D programs were properly apportioned. However, the second criteria, the relative effectivenss of the projects, were not accurately assessed resulting in some significant project failures. A contributing factor to any accurate effectiveness measures has been the general lack of quantitative data on the cost and performance of both existing "state-of-the-art" equipment and advanced designs. In addition to the reliability data bank information being developed under another UMTA program, data will be collected on this program to improve the process of project prioritization.

Looking at the future rail transit market it appears that a shift in the apportionment of capital grant funds to the several categories will occur. This ten year outlook prepared within UMTA presages increased spending on civil structures relative to rolling stock. Although the factors of relative effectiveness and R&D phasing must be considered it seems that a similar shift in R&D budget may be justified.

Examination of variable (operating and maintenance) transit cost aids in identifying the areas for highest potential impact. The figure illustrates the breakdown of O&M outlays by major activity areas for six rapid rail properties. The major opportunity for urban rail R&D is considered to be within the three areas of maintenance of ways and structures, maintenance of equipment and power. Although the transportation function or the cost of operating the system is heavily affected by institutional constraints, technology can indirectly provide productivity improvements.

The next major program element is entitled vehicles, equipment and deployment. It includes the Subsystem Technology Application to Rail Systems (STARS) Program, railcar standardization, maintenance improvements, product introduction and the Transportation Test Center (TTC).

The objectives of the STARS program are to identify rapid rail transit technical and operational problems, apply existing technology to their solution and demonstrate/deploy these solutions in the near-term. Generally a time span of 3-5 years is anticipated as being realizable goal for a majority of the STARS program elements. The approach being used to develop the program has involved contacting and assessing the technical problems of the U.S. transit operators. In this regard, the properties which have been assessed include NYCTA, MTA, PATH, MDTA, CTA, TTC, WMATA and BART. Also the American Public Transit Association (APTA) has been instrumental in the assessment and the interpretation of data which will result in STARS projects. APTA also coordinates with the transit properties in obtaining additional quantitative data as well as reviewing the STARS project priorities. A general objective for the selection of STARS projects is that the cost of the technology application and deployment will be recovered by the reduced operating costs.

The initial phases of the STARS selected projects will consist of subsystem analyses and quantitative definition of current equipment performance and cost. This approach will provide some of the inputs to the cost/benefit models to be used as a part of the research prioritization process. A listing of those subsystems which will be evaluted during this fiscal year are presented.

The rail car standardization project represents a soft-technology approach to solving some of the transit problems. The rapidly escalating cost of rail cars and the uniqueness of each rail car procurement provided the impetus for evaluating the feasibility of rail car standardization. The program is structured to develop an interchange of opinions between the property users and rail car suppliers with UMTA acting as the official judge in areas of dispute. During the last year, rail car procurement terms and conditions guidelines were issued. In addition, joint rail car procurements between Miami and Baltimore and Cleveland and Philadelphia were arranged. The development of performance specifications and subsystem dimensional and interface standards is an on-going effort this year. Another activity will focus on revision of the standard light rail vehicle specification to include both 4 and 6 axle vehicles based on current value engineering cost reduction analyses.

As noted, maintenance operations represent an area for increased productivity through technology improvements. An initial study into the environmental conditions in transit maintenance facilities and their effect on productivity and equipment reliability will be conducted.

The deployment of technology results into actual rail operation is the ultimate goal of our R&D programs. One of the obstacles to deployment has been the lack of sufficient funds to carry the hardware from the prototype feasibility to the pre-production stage. Recent legislation has provided capital grant funds for the express purpose of product introduction. A project to deploy energy storage flywheels on NYCTA railcars is planned this year under this new product introduction mechanism. A 2 year evaluation of the track geometry measurement system by the NYCTA is another example of successful deployment.

The final element of this program is the Transportation Test Center in Pueblo, Colorado. The facilities at the Center provide for extensive testing and evaluation of transit vehicle equipment and in the future the Center will assume a greater role in the qualification of vehicles. An often cited and valid concern is that the Center test environment does not accurately reflect that of the operational properties. The Center will never be a complete substitute for on-property testing but the current activities at TTC are aimed toward improving its applicability to transit environments.

An automated solid state power station which will provide the opportunity to control track power levels and harmonics and to evaluate regeneration is near completion. This new equipment will also improve the capability to understand electromagnetic interference problems which have become a major design concern as a result of the increasing use of electronics on vehicles

and transit systems. Design of a perturbed track is also scheduled for this year to provide the capability to evaluate the influence of track perturbations on vehicle response - this will support the wheel/rail dynamics program described below.

The last program element, system integration, addresses problems which have systems-wide ramifications. It include projects to treat elderly and handicapped (E&H) issues, dynamics and noise abatement technology and national design guidelines.

The E&H program is designed to examine the problems of rail transit system accessibility and to develop rational solutions where practicable. In response to a Congressional mandate, an analysis of light and commuter rail system accessibility will be conducted. Rail rapid accessibility is being assessed under another element of the Office of Technology Development and Deployment. Also, development of a wheelchair lift for light and commuter rail vehicles is scheduled for this year with emphasis on design analysis in the initial phases prior to committing to hardware manufacture. The need to completely understand the total system implications of accessibility prior to developing solutions which might prove impractical is a major goal of our E&H efforts.

The noise abatement technology program is intended to reduce the impact of noise from existing and presently planned transit systems through the development and implementation of improved, cost-effective methods and hardware. A great deal of analysis has been directed toward defining the sources of noise generation and the current noise levels of each domestic urban rail rapid system. The first major area of emphasis was aimed toward evaluating methods for reducing one of the major sources, wheel/rail noise; significant reductions in general on the order of 15 dBA were demonstrated. During the source evaluation phase, it was determined that propulsion system generated noise is as significant a source as wheel/rail interaction and future research toward reducing noise levels at this source are planned. The noise abatement program is an excellent example of successful deployment or research results; a number of properties have used the noise abatement guidelines developed under this program and have incorporated the improvements into their systems.

This year the noise program's activities include development of analytical techniques supported by empirical data measurement for evaluating noise sources in elevated transit structures and groundborne noise. A wheel/rail dynamics program is planned as an adjunct to the noise program to evaluate rail and vehicle interactions and define the relationships between vehicle and track design and performance parameters. A project to measure vehicle induced forces and a grant to CUTD to evaluate several track fixation system configurations are scheduled for this fiscal year under the construction portion of the program to support this activity. The design phase for the development of a steerable truck which offers the potential of reduced wheel/rail wear as well as noise abatement is also scheduled during FY 1979.

CUTD to evaluate several track fixation system configurations are scheduled for this fiscal year under the construction portion of the program to support this activity. The design phase for the development of a steerable truck which offers the potential of reduced wheel/rail wear as well as noise abatement is also scheduled during FY 1979.

The final project under system integration is National Design Guidelines. For many years, UMTA has perceived that for each new rail system a new set of design criteria and standards was developed. In addition, since UMTA had no objective criteria by which to evaluate system specifications, the need for developing national rail rapid transit design guidelines became obvious to both UMTA and transit operators. The National Design Practices Manual project is a two phase project in which the operators through APTA will prepare an outline of the Manual in the first phase. A contractor to be selected competitively will actually write the manuals in Phase 2. The manuals will represent standards of the best available technology and design criteria for various transit system elements. APTA's role in the next year is to assemble a bibliography on all existing design criteria guidelines or standards, and prepare a detailed outline for the manual.

As noted by previous speakers, UMTA's rail technology program has gone through an era that emphasized total vehicle development. It is moot to debate any further the wisdom of this approach; the expensive learning process is over. The program has been restructured in answer to many of the recommendations provided at previous priorities conferences. I believe my presentation has demonstrated this with the evidence of increased program emphasis on near-term development, trade-off analyses, and system quantification and integration.

OFFICE OF RAIL AND CONSTRUCTION TECHNOLOGY

OFFICE OF TECHNOLOGY DEVELOPMENT AND DEPLOYMENT

URBAN MASS TRANSPORTATION ADMINISTRATION

U. S. DEPARTMENT OF TRANSPORTATION

PRIOR RAIL R&D ISSUES

- NON-UNIFORM PROCUREMENT PRACTICES AND SPECIFICATIONS
- TRADE-OFF BETWEEN PERFORMANCE, ECONOMY, EFFICIENCY AND RELIABILITY
- EVOLUTIONARY NOT REVOLUTIONARY R&D
- EMPHASIS ON NEAR TERM DEVELOPMENT/PRODUCT IMPROVEMENT
- IMPROVED QUALITY-ASSURANCE OF EQUIPMENT
- FOCUS ON OPERATING PROBLEMS AND NONHARDWARE SOLUTIONS
- INCENTIVES TO SPUR INNOVATION
- SUFFICIENT TESTING AND QUALIFICATION

RAIL TECHNOLOGY

REQUIREMENTS ANALYSIS AND EVALUATION

- MARKET ANALYSIS
- COST MODELS
- SYSTEM TRADE-OFFS (COST, PERFORMANCE AND SAFETY)

VEHICLES, EQUIPMENT AND DEPLOYMENT

- SUBSYSTEM TECHNOLOGY APPLICATION TO RAIL SYSTEMS (STARS)
- STANDARDIZATION
- MAINTENANCE IMPROVEMENTS
- PRODUCT INTRODUCTION
- TTC

SYSTEM INTEGRATION

- ELDERLY AND HANDICAPPED
- DYNAMICS AND NOISE ABATEMENT TECHNOLOGY
- NATIONAL DESIGN GUIDELINES

RAIL TECHNOLOGY

PRIORITIZATION CRITERIA

- MARKET SIZE
- RELATIVE EFFECTIVENESS
- R&D PHASE

UMTA SECTION 3 RAIL MODERNIZATION PROJECTS

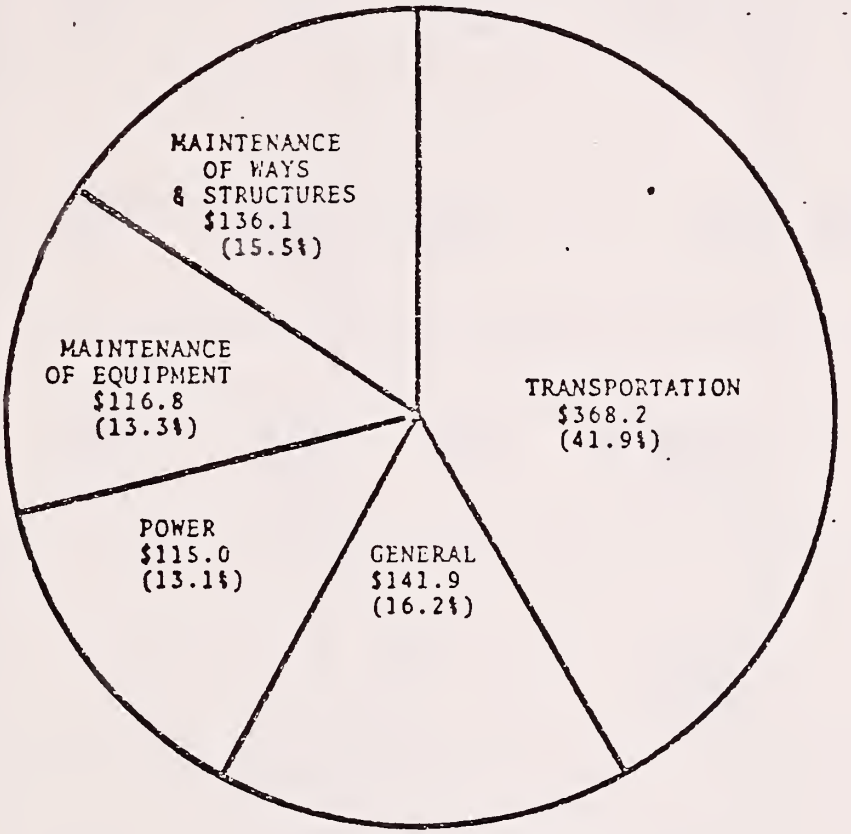
2/65 - 5/77

NET PROJECT COST (FEDERAL AND LOCAL SHARES)

	TOTAL RAIL		RAPID RAIL		LIGHT RAIL		COMMUTER RAIL	
	$ (000s)	% of Total	$ (000s)	% of Total	$ (000s)	% of Total	$ (000s)	% of Total
1. Rolling Stock	1,321,751	53.8	473,503	41.1	130,660	43.4	717,588	71.7
2. Rights-of-Way	659,966	26.9	341,047	29.6	97,313	32.3	221,606	22.2
3. Stations and Terminals	274,631	11.2	217,400	18.9	27,197	9.0	30,034	3.0
4. Yards and Buildings	64,598	2.6	45,863	4.0	18,713	6.2	22	-
5. Operational Improvements	86,846	3.5	52,232	4.5	26,866	8.9	7,748	0.8
6. Other	47,013	1.9	23,206	2.0	119	-	23,688	2.4
	2,454,085	100.0	1,153,251	100.0	300,868	100.0	1,100,686	100.0

THE RELATIVE SIGNIFICANCE OF MAJOR MODERNIZATION PROGRAM AREAS

	TOTAL RAIL		RAIL RAPID		COMMUTER RAIL		LIGHT RAIL	
	12 Yr. History	10 Yr. Outlook	12 Yr. History	10 Yr. Outlook	12 Yr. History	10 Yr. Outlook	12 Yr. History	10 Yr. Outlook
Rolling Stock	53.8%	20.7%	41.1%	17.1%	71.7%	22.1%	43.4%	47.6%
Rights-of-Way	26.9	49.3	29.6	50.1	22.2	50.4	32.3	25.1
Fixed Facilities	19.3	30.0	29.3	32.8	6.1	27.5	24.3	27.3
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%



TOTAL: $878 Million[2]

1. Six operations are:
   NYCTA
   CHICAGO
   PATH
   PATCO
   SEPTA
   CLEVELAND
2. All rapid rail (excluding commuter rail) stated in 1978 dollars is about $1.3 billion.

COMBINED OPERATING AND MAINTENANCE BUDGETS
OF SIX RAPID RAIL OPERATIONS FOR 1975

RAIL RAPID TRANSIT CAR REPLACEMENT MARKET**

1976-2000

SIZE OF CARS/ TRANSIT AUTHORITY	1976-1980	1980-1985	1985-1990	1990-1995	1995-2000	TOTAL
LONG						
NYCTA (IND-BMT)	754*	410		1350	1000	3514
MBTA (RED)				92	76	168
GCRTA	60				30	90
SEPTA (B.S.)	125					125
PATCO					75	75
LONG CAR-TOTAL	939	410		1442	1181	3972
SHORT						
PATH			50		206	256
CTA	200*	570		180	150	1100
MBTA (ORANGE)	120*					120
MBTA (BLUE)	70*					70
SEPTA (M.S.)				270		270
NYCTA (IRT)		350	1310	1200		1860
SHORT CAR-TOTAL	390	920	1360	1650	356	4676
LONG-LOW						
BART					450	450
WMATA					300	300
LONG-LOW CARS-TOTAL					750	750
TOTAL	1329	1330	1360	3092	1537	8648

* ORDER PLACED OR DELIVERIES COMPLETED

** ASSUMED 35 YEAR LIFE EXPECTANCY FOR NYCTA CARS; 30 YEARS FOR ALL OTHERS

RAIL TECHNOLOGY

VEHICLES, EQUIPMENT AND DEPLOYMENT

STANDARDIZATION

- TERMS AND CONDITIONS GUIDELINES ISSUED
- DEVELOPMENT OF PERFORMANCE STANDARDS AND INTERFACE REQUIREMENTS
- LRV SPECIFICATION REVISION

STARS

- SUBSYSTEM ANALYSIS AND QUANTIFICATION
  - MODULAR A/C
  - STATIC INVERTER
  - DOOR IMPROVEMENT
  - FARE COLLECTION
  - PROPULSION SYSTEMS
  - ESCALATORS
  - THIRD RAIL DEICING

MAINTENANCE IMPROVEMENTS

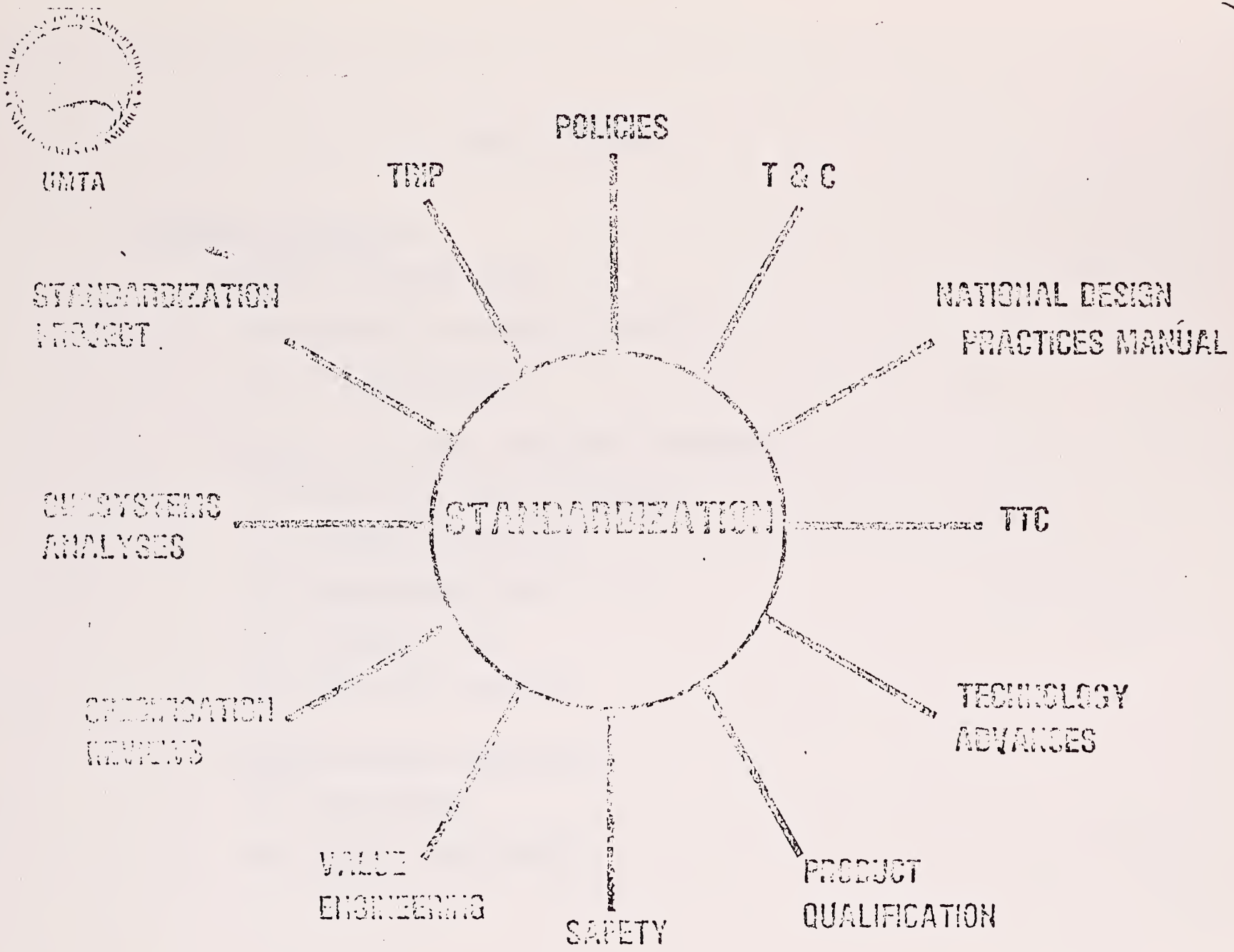
- ENVIRONMENTAL EFFECTS

PRODUCT INTRODUCTION

- NYCTA FLYWHEEL PROGRAM
- TRACK GEOMETRY MEASUREMENT SYSTEM

TIC

- PERTURBED TRACK
- POWER STATION


POLICIES
UMTA
TINP
T & C
STANDARDIZATION PROJECT
NATIONAL DESIGN PRACTICES MANUAL
SUBSYSTEMS ANALYSES
STANDARDIZATION
TTC
SPECIFICATION REVIEWS
TECHNOLOGY ADVANCES
VALUE ENGINEERING
SAFETY
PRODUCT QUALIFICATION

RAIL TECHNOLOGY

SYSTEM INTEGRATION

ELDERLY AND HANDICAPPED

- ANALYSIS OF LR AND CR SYSTEMS
- LIFT DEVELOPMENT

DYNAMICS AND NOISE ABATEMENT TECHNOLOGY

- WHEEL/RAIL SOURCE EVALUATED
- ELEVATED STRUCTURES
- GROUND-BORNE NOISE
- STEERABLE TRUCK
- WHEEL/RAIL DYNAMICS

NATIONAL DESIGN GUIDELINES

- BIBLIOGRAPHY
- OUTLINE DEVELOPMENT

ROBERT L. MAXWELL
TRANSPORTATION GROUP MANAGER
OFFICE OF TECHNOLOGY ASSESSMENT

The Office of Technology Assessment, an agency of the Congress, has been involved in urban transportation and rail system studies almost since its formation six years ago. Responding to requests of the various Congressional committees having jurisdiction over authorizations, appropriations, oversight and legislation, OTA has carried out a number of studies concerning various aspects of federal policy in the field of transportation. Among these was a study conducted for the House Appropriations committee on the subject of UMTA's Urban Transit Vehicle Demonstration Programs -- TRANSBUS, SOAC, and ACT-1.

Among the findings of this study were that:

- o There was insufficient emphasis placed on development of key components required for transit vehicles and facilities, such as implementation of low floor technology in TRANSBUS.
- o ACT-1 appears to have had problems because it attempted new component development simultaneously with the integration of this technology in a new vehicle design.

- o A consistent policy guiding federal involvement in the research, development and deployment processes is necessary if this policy is to have a positive result acceptable to transit operators, manufacturers and the public.

- o Transit operators should be an active participant in all stages of the development process.

- o Extensive evaluation and demonstration of R&D results are necessary if new technologies and systems are to be successfully introduced into revenue service.

It is with great satisfaction, therefore, that we have learned, through Steve Teel's excellent presentation on UMTA's Rail and Construction Technology program, that this activity is currently concentrating on subsystem technology, and that the industry through APTA, is closely involved in the planning and evaluation of these R&D efforts. It is also appropriate that the emphasis, at this time, be on the application of existing technology to the solution of current problems. UMTA, and especially my good friend George Pastor, are to be complimented on the direction given to the program. The industry, through the auspices and direction of APTA, and the Transportation Systems Center, are also to be congratulated on the part they have played in this program.

The Office of Technology Assessment, as many of you I am sure are aware, was established by the Congress with the basic function of helping legislators anticipate and consider the consequences of technological applications in determination of public policy on existing and emerging national problems. Accordingly, OTA is charged with securing for the Congress, competent, unbiased information concerning the physical, biological, economic, social and political effects of such technological applications. In carrying out this function, OTA is expected, among other things, to identify alternative technological methods of implementing specific programs, to identify alternative programs and policies for achieving requisite goals, and to make estimates and comparisons of the impacts of alternative methods and programs. OTA does not try to represent the views of the legislative branch, or vice versa. We provide information to the Congress. We do not attempt to make recommendations to the Congress, and the views expressed herein are entirely the views of the speaker.

At the request of the Senate Commerce Committee we have been engaged in a study of the future of the automobile which has, of necessity, involved us in an examination of the potential for development of alternatives to the personal automobile, such as mass transit. We see great advantages to society if sigificant increases in public transportation facilities for urban areas can be made available, along with positive incentives for the public to make more extensive use of these facilities.

We also have examined the potential constraint of a shortfall in petroleum supplies in the late 1980's or 1990's, and believe that this should be a serious consideration in planning transportation systems for the future.

One of the major roles of R&D in urban rail systems, under these projected conditions, is of course to assure that proven technology is available to improve the service and performance characteristics of these systems, to reduce life-cycle costs, to reduce energy consumption, and to make these systems more attractive so that increased ridership will be assured. However, the application of existing technology may not be sufficient, in the long run, to achieve these goals. A program which fosters innovation, or "builds acceptance for innovation," by the industry, in propulsion, and braking energy conservation, communication and control, structures, mechanical components, and safety design is essential if we are to realize the full potential of urban rail systems.

The Advanced Concept Train, ACT-1, is one example of the attempt to provide innovation in the design of urban rail vehicles. The program was surrounded by controversy, and plagued by programatic and engineering problems from its inception. I am pleased, therefore, to learn that the test program is nearing completion and I am told that much valuable engineering information

has been obtained, both on components as well as on the complete system, which will contribute to the improvement of future systems. I believe that an objective and critical appraisal of this program, now that it is drawing to a close, would be of great interest to UMTA, DOT, OMB and the Congress. It would undoubtedly assist the decision makers in their consideration of future R&D policy in urban transportation. Among policy issues which arise from a program such as ACT-I are: the appropriate role of the Federal Government in funding R&D programs, the type of program which should be funded, the extent to which prototype vehicles and systems should be included in such programs, and, most important, ways that industry and the government can work most effectively in planning and implementing future programs. What is clear from these issues is that the R&D policy process cannot be considered in a vacuum. It must be seen in the context of future government policy related to urban passenger travel, future alternatives to such travel and the host of social, resource, and environmental conditions which surround present and future policy.

One final comment. It was stated yesterday that "we should not invent new mousetraps, but make the mousetraps we have work." I guess I do not understand why we cannot do both. In addition to working on improvements and solutions to problems of existing systems, we should always be looking for new ideas and new design approaches for components, sub-systems and systems for future applications.

RAIL TECHNOLOGY

PROGRAM EMPHASIS

- NEAR TERM DEVELOPMENT/PROBLEM SOLVING
- QUANTIFICATION OF CURRENT SYSTEMS
- TECHNOLOGY TRADE-OFF STUDIES
- SYSTEM LEVEL ANALYSIS AND INTEGRATION

Deane N. Aboudara, Director
Technical & Research Services Department
American Public Transit Association
Washington, D.C.

With the advent of the Urban Mass Transportation Act of 1964, great optimism and enthusiasm for the resurgence and growth of transit contributed materially to the "technology syndrome."

It is not without merit to consider the possibility that "technology" and all it signified could establish "image," yet be counterproductive to the fundamental of "need." There was "need" to obtain attention, because the general impression of transit was that of extreme obsolescence. The path identified then, to obtain support, was to strive for a level of technology that overcame the perceived obsolescence factor, or the old-fashioned image. Developing this technology "package," however, was not without risk.

Probability of success can be severely impacted when what appears to be a relatively low level of new technology is introduced without an evolutionary period of adoption. We have readjusted our perspective and we are now, in various ways, trying to reconstruct a market place that is viable and based upon realistic expectations.

The matter of Standardization and Vehicle Testing gained prominence and recognition when the cost of the vehicles appeared to be escalating at an unprecedented rate -- and the product being provided was, upon occasion, suffering from severe reliability problems. "Technology" was becoming the "kiss of death."

So -- the apparent indication that vehicle costs were on an unreasonable growth curve and the product at the same time was experiencing reliability difficulties, brought UMTA into the picture to support what should be done and how to do it.

Here are some observations to share with others of you who know there is a growth market which can be competitive, profitable, and still provide value to the purchaser and user.

Steps can be taken to stabilize costs and improve product reliability. The low-first-cost factor as the means to determine the equipment to be purchased, for example, should be discarded. When a purchase price is in the per-unit range of $0.5- to $1-million, and the usable life is 30-40 years, it would appear that the method of procurement should be some-

what more sophisticated and responsive toward encouraging designs with secondary cost benefits. Showing more concern over the cost to repair and maintain, the need for innovation and product improvement, and a product the buyer can have confidence in will establish an atmosphere of encouragement and incentive rather than one of high risk and penalties.

In my opinion, however, standardization of components and subsystems will not yield any significant economic advantages. What then happens to technological improvements? Are they to be cast aside because of a departure from the standards? Of course not.

Car body structures are a good subject to consider. What is their contributed value? How is the tooling (nonrecurring costs) written off for subsequent orders? How is a competitive field maintained? Car body structures are not where the problem lies. A "family" of sizes has some attraction, but the production and tooling techniques are going to vary with the number of manufacturers.

There would appear to be some cost savings potential in the standardization of the application of hardware. Modularity, consistent under car equipment arrangement, common electrical and mechanical interface considerations are part of the answer to benefits from standardization.

While not associated with "standardization" because of not being in the realm of technology, is another area which deals with the matter of business risk associated with Terms and Conditions, the contractual requirements. Transit operators have acknowledged that many aspects in this area should be re-examined and re-considered from the seller's viewpoint, while maintaining the seller's obligation to the buyer. Substantial progress has been made through the recently issued guidelines by UMTA, but there is still room for improvement. This form of standardization should be beneficial toward stabilization of costs.

From my perspective, Vehicle Testing is an element of Standardization.

It is foolhardy and expensive to innovate on the production line. Realistic production schedules and first article delivery dates must evolve to permit the initial equipment configuration to be properly checked out and tested in order to provide timely feedback into the production line. Getting to the matter of reliability, with proper design, application engineering, quality assurance and manufacturer planning, the only provision in the production line schedule should be for "start-up" type disturbances. Major problems of propulsion, brakes, trucks, doors, air conditioning, etc, and all the integration of the components and subsystems should not manifest themselves as production or manufacturing constraints. This has been a prime source of reliability problems, because there has not been proper recognition of the need for a vehicle "gestation" period. A deliberate process needs to be implemented to "certify" such items and establish an inventory of proven equipment. Such recognition has been confirmed by the UMTA in the initiation of a project identified as Rail Car Standardization.

The foregoing is suggesting a formalized procedure of not only "vehicle" testing, but testing and certification of the ingredients that comprise a vehicle which must attest to the reliability and performance intended.

This then moves to the "how, where and who" now that we have agreed on "what" should be done. I say agreed because the transit legislation just signed by the President does include language to permit funding for product improvement and innovation within the context being discussed.

In closing, the balance of these remarks deal with the Technology Delivery System which is what the new legislation has now legitimitized.

In existing transit systems, numerous areas must be upgraded to improve energy usage, to be able to assume a more active role in accomodating additional ridership, to develop more efficient operation of the physical plant, and to apply effective means of assuring a high level of safe, reliable and responsive service to the public. New systems will also benefit from such efforts, but the justification for implementation of an on-going technology delivery system should not be on this basis alone.

The previous technology delivery system of private industry has not failed - it has vanished. This was because the market no longer provided justification for such private corporation investments. The transit operators have tried, and in many cases, implemented activities to test and evaluate technological innovation, but these have been few and far between. There has not been the financial support elsewhere to fill this "void." The answer lies in making the technology delivery system that was successful, once more viable.

This will require a significant funding level if the job is to be done on a comparable basis as was performed in private industry previously.

Because the federal government basically has the control of the funds, it is also affecting the technology delivery system. This recognition in the current legislation is a milestone and UMTA is to be applauded for its efforts of being responsive to the needs of the industry.

RAIL AND CONSTRUCTION TECHNOLOGY II

Chairperson: *Stewart B. Hobbs*, Director, Office of Ground Systems, Transportation Systems Center

UMTA'S RAIL AND CONSTRUCTION TECHNOLOGY PROGRAM: CONSTRUCTION TECHNOLOGY, WAYS AND STRUCTURES: *Russell K. McFarland*, Director, Office of Rail and Construction Technology, UMTA

Panel: *Richard E. Thayer*, Manager-Design and Engineering, Metropolitan Dade County Transit System, Miami, Fla.

Harry Sutcliffe, Project Manager, Bechtel, Inc.

Richard S. Fountain, Senior Industry Representative, U. S. Steel Corporation

John F. Hoban, Director, Rail Transportation Department, Port Authority of New York and New Jersey

Reporter: *Robert J. O'Connor*, Transit Systems Branch, Transportation Systems Center

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RAIL AND CONSTRUCTION TECHNOLOGY II

RUSSELL K. McFARLAND
DIRECTOR, OFFICE OF RAIL AND CONSTRUCTION
TECHNOLOGY II
URBAN MASS TRANSPORTATION ADMINISTRATION

Let me start off by providing a very brief background. We in UMTA have been in construction R&D for several years, in conjunction with efforts that were coordinated in the Secretary's office, with Federal highway and Federal railway.

Early in the 1970's, the Secretary's office became concerned about "construction costs" and the proliferation of R&D within UMTA FHWA and FRA, each going different ways. As a result OST coordinated a joint UMTA, FHWA, FRA tunnel of R&D program. Late 1977, the lead responsibility for this program was moved to UMTA; and at that time we were asked to redefine the program and define program goals. Since early 1972 we had a clearly defined program goal, and it was an easy one -- reduce costs! In construction we did not worry about policy. We didn't have to worry about whether a rail system was built in this city or that city. We pick up from the point where the planners have decided that a rail system shall be built. The bottom line of the construction program has been and is presently trying to address the cost of these rail systems.

The graphs that I'll show you will outline what we are presently doing in UMTA and where we plan to going in the new few years.

May I have the first view graph please? Introduction.

Traditionally in UMTA, construction R&D has been pretty much of a second cousin, only because it was difficult to get

a hold of, in that many of our R&D constituency was primarily interested in the operating systems, not in systems to be built. We've defined the program within UMTA now in three areas, requirements analysis and evaluation, technology, and systems integration and deployment. Let me step through each of these briefly.

In the requirements analysis and evaluation, what we're trying to do is get a handle on what our needs are and what the payoffs are for the specific needs. In looking at costs, we try to establish a payoff for the R&D investment. R&D to me is a business, and if we can't show a profit for the investment of the R&D dollars then there's something wrong with our R&D priorities. It's a bit mercinary but I think in construction and construction related technologies, it is the only option we have at this time.

We have efforts in trying to catalog the urban rail systems that we have in the United States, what type of rail system we have, where they are, what their age is, the type of system.

We have another effort to develop construction costs, through modeling in conjunction with the development of a data base. One of our biggest problems is trying to confirm estimates for new systems that are coming up for capital funding. We have no means currently to say yea or nay on estimates of new systems when they're asking for Federal commitments on construction.

Then, of course, maintenance and rehabilitation is a costly area. I believe we're entering into a period where Congress

will be putting more and more money into modernization of our existing rail systems. What does it mean to us? What does it means to our priorities? We haven't even begun to try to address the questions of how do you bring up to 1978 standards systems like Boston or New York, particularly out in the Queens, New York.

In technology, three or four years ago within this program in a review like this, we would have talked about nothing but technology. Our whole perspective was technology. We've gone through a bit of an evolution. Technology is part of our program; a very important part but equally important, we feel, is understanding needs and how technology is put to use.

In the design and construction area, we're looking at vehicle induced forces on track systems, we're looking at ties, transit track design standards, and elevated structure design criteria.

Some of you may be aware of what current elevated structure criteria exists. I am constantly intrigued with seeing AASHTO criteria appearing in rail elevated structure criteria for rail vehicle. AASHTO is a highway design specification document that most of you are familiar with. It was developed for the interstate highway system. Over and over again I see a 0.3 vertical dynamic load factor that has no logic or application to elevated rail structures, but it's use is tradition.

In ground movement and control early in the program we concentrated in tunneling. It was the area that was the least understood and the most costly in urban rail construction. We still have a fair effort in tunneling, in design techniques, in

standards, and one fairly long-term effort, the excluded tunnel-liner system. For short-term R&D items we are looking at joint sealants, we're doing a fair amount of instrumentation work with the MBTA slurrywall, also evaluating instrumentation data that's been taken by the University of Illinois over a number of years in Washington, D. C. and looking at the Berkeley Hills tunnel in BART which goes through the Hayward fault.

Environmental factors: we are looking at emergency ventilation in tunnels by modifying the environmental program that was put together to design ventilation for underground rail systems. We're looking at socioeconomic impact of tunneling and the question of how can we minimize the impact to urban environments when we go into a city and try to build subways.

Contracting and management practices has been an area that I think we're beginning to appreciate more and more, particularly the need for a better understanding of some of these elements. Risk allocation: a study that is currently very modest, initiated with M.I.T. When we look at construction costs from a technology standpoint, for years we've said, "We don't require new technology, we have technology that has been in use for years throughout the world, that we can't get it in operation here in the United States." We're beginning to better understand the reasons for this lack of innovation, by the way we manage the construction of rail systems and the lack of concern on our park for risk and liability associated with innovation.

We currently have a fair effort going on in the grants assistance side of UMTA trying to redefine our entire stance on

project management. When we come out of alternatives analysis with a city like Los Angeles we say, "Gee, a fixed rail system is the proper thing here, what should we be asking of the authority, what control should we be putting on them, what constraint should we be asking for? What incentive should we be building in?" Currently we do nothing. Each different city is run in a different way. We have no criteria, no standards, no guidelines. And I keep coming of a door that says that many of our technical problems directly result from a lack of understanding of the manner in which we try to put the technology into use through these new or existing authorities.

Let me get to the last slide, or the next to the last slide. Systems integration and deployment: this is an area where we have a good sized effort going, we feel that the technology that we invest R&D money into is not completed until it is put into use. We have efforts underway with technology deployment, looking at new approaches to designing tunnels in certain types of soil, in ventilation, and in risk allocation and inservice guidelines. We would like to better understand how to define insurance coverage for a $500 to $600 million system. Premiums on some of the professional liability insurance are running up to 25 percent of the coverage. How do we define insurance programs such that extraordinary risks are adequately covered for your consultants, and at reasonable costs? Insurance on these major systems now is running two, three, maybe even four percent of the construction cost. The potential payoff for reducing insurance costs makes some of our other technical payoffs look

small in comparison.

Our current deployments efforts underway include an effort going with Miami assisting them in trying to verify the use of double T's box girders. We're working with Chicago on evaluating different types of fasteners and ties with regard to their ability to dissipate noise or reduce noise problems. In tunneling we have some seven efforts going on, all of them underway through authorities, with the actual implementation being done by authority engineering staffs, or the consultants of the authorities. This, again, has been one of our pushes, to get the operating organization's directly involved in implementations of R&D, rather than UMTA staff. We feel in this way that we can best bring out deployment of new technology.

I'd like to wrap up with a little entertainment and show you what some of these words mean. I picked a couple of slides out of our slide library to show you. We have battered around the word slurrywall. This slide shows an excavation in Paris, about two years ago. That excavation is about six stories deep. You might be struck by the fact that there are no braces, in fact you don't see any wall support at all. It's very dramatic. The wall on the left dates back probably well before Portland Cement existed. The building in the center is a national monument they had to maintain, so they built around it. Very dramatic technology. We have very slowly been trying to bring this technology into our construction, again I think because of our lack of sensitivity to risk involved in changing technology, the pace of change has been very slow.

The Environmental Impact Statement is a question that is being addressed right now in the Grants Assistance Office. There has been considerable effort on trying to figure out how to live with EIS requirements and yet break the Catch 22 question on these transit systems. Our current EIS procedures require that we perform an alternative analysis for new systems or extensions to existing systems and define the alternative sufficiently to make a selection between bus, other options, and rail, and that we definitize this in a document, the EIS, defining the environmental impacts before we can go into any preliminary engineering. To do that, you require information that can only be developed through preliminary engineering. The question is how do we break of this situation. There have been several recommendations. One is to split the EIS into a preliminary and final, but the lawyers keep telling us that the laws require that a final EIS be provided before you move from the alternative analysis to engineering before you put any money into engineering for a preferred mode.

Another option is to do a tie red EIS. Do your EIS and then come with a supplemental. We can do that right now. But what's the incentive once you've gotten through your eleventh draft as happened in Buffalo and you find that by changing a design you could save several million dollars but you'd have to reopen your EIS? I don't know if the director of engineering for Buffalo is here but I doubt if he would hesitate a minute to tell me that he would rather not reopen the EIS, and the savings of money, that's the way the game goes.

We're trying to wrestle with it. We're going to be wrestling with it at a conference in Williamsburg in December. I don't mean

to put a plug in for that conference but -- We're having a conference in Williamsburg to address issues associated with the alternatives analysis, and planning, -- defining new rail systems up to the point where they can come in and seek full funding commitments from UMTA for construction. Currently we seem to have a different approach to every different system. We have no uniform procedure. Our new rail construction costs are by some perspectives astronomical. And much of it, we think, is directly attributable to our planning process. That we have no incentive under this system, right from the start, to be sensitive to cost. We have incentives to be sensitive to the EIS. We have incentives to get through bureaucratic paperwork but nowhere do we have incentives that say: Hey, we've got to come in with better costs or we're not going to be building these systems.

As I said, December 7th and 8th we're going to have a conference in Williamsburg to address a number of these issues. Can we split the EIS up? Can we redefine incremental funding? Can we change the process leading to full funding commitment? Can we get the government out of the way once we've made a commitment?

In Atlanta we have a full funding agreement with the authority there where they have committed to build 13.7 miles of subway for $1.016 billion. Our commitment in turn is to stay out of their way. We don't sign off on procurements below a certain level. We don't require their approval to proceed. We post-audit them. And if they've got their hand in the cookie jar the GAO is going to give them trouble, but we're not. We had a case a few years back where the project was brought almost to a halt over the cost of buying Xerox machines. Now

that really hurts economy., What procedures do we set up? I think our administrator, our policymakers, are serious in trying to seek counsel from the industry in redefining these procedures.

OFFICE OF RAIL AND CONSTRUCTION TECHNOLOGY

OFFICE OF TECHNOLOGY DEVELOPMENT AND DEPLOYMENT

URBAN MASS TRANSPORTATION ADMINISTRATION

U.S. DEPARTMENT OF TRANSPORTATION

CONSTRUCTION TECHNOLOGY

REQUIREMENTS ANALYSIS AND EVALUATION

- NEEDS ANALYSIS
- COST ANALYSIS AND ESTIMATES

TECHNOLOGY

- DESIGN AND CONSTRUCTION CRITERIA
- GROUND MOVEMENT PREDICTION AND CONTROL
- MAINTENANCE AND REHABILITATION
- ENVIRONMENTAL FACTORS
- CONTRACTING AND MANAGEMENT PRACTICES

SYSTEMS INTEGRATION AND DEPLOYMENT

- TEST SECTIONS AND DEMONSTRATIONS
- WORKSHOPS AND DEMONSTRATIONS
- PUBLICATIONS

CONSTRUCTION TECHNOLOGY

REQUIREMENTS ANALYSIS AND EVALUATION

- TRACK SYSTEM STUDY (ENSCO)
- CONSTRUCTION COST ESTIMATING MODELS AND DATA BASE (TO BE SELECTED)
- MAINTENANCE AND REHABILITATION REQUIREMENTS STUDY (TO BE SELECTED)

CONSTRUCTION TECHNOLOGY

TECHNOLOGY

DESIGN AND CONSTRUCTION

- VEHICLE INDUCED FORCES (KAMAN SCIENCES)
- CONCRETE TIE PROTOTYPE TESTING (PCA)
- TRANSIT TRACK DESIGN STANDARDS (TO BE SELECTED)
- ELEVATED STRUCTURES DESIGN CRITERIA
  (MIT & HARRINGTON, DUNN & GEORGE)

GROUND MOVEMENT AND CONTROL

- SOFT GROUND CONTROL DESIGN TECHNIQUES (STANFORD U.)
- TUNNEL LINER DESIGN STANDARDS (U. OF ILLINOIS)
- EXTRUDED TUNNEL LINER SYSTEM (FOSTER-MILLER)
- TUNNEL LINER SEALANTS (USBR)
- MBTA SLURRY WALL INSTRUMENTATION (TO BE SELECTED)
- WMATA INSTRUMENTATION DATA EVALUATION (U. OF ILLINOIS)
- BART INSTRUMENTATION DATA EVALUATION (BART & U. OF CALIFORNIA)

ENVIRONMENTAL FACTORS

- EMERGENCY VENT./SES MOD (PBQD)
- SOCIAL/ECONOMIC IMPACT OF TUNNELING (ABT ASSOC.)

CONTRACTING AND MANAGEMENT PRACTICES

- RISK ALLOCATION (MIT)
- PROJECT MANAGEMENT STUDY (BRAB/NRC)

CONSTRUCTION TECHNOLOGY

SYSTEMS INTEGRATION & DEPLOYMENT PLANNED

- PAT NEW AUSTRIAN TUNNELING METHOD (GRANT)
- EMERGENCY VENTILATION PROCEDURES DEMO (GRANT)
- RISK ALLOCATION GUIDELINES (UTD CONTRACT)

CONSTRUCTION TECHNOLOGY

SYSTEMS INTEGRATION & DEPLOYMENT UNDERWAY

ELEVATED STRUCTURES

- MIAMI FULL-SCALE TEST OF DOUBLE TEE GIRDER (GRANT)

TRACK AND WAYSIDE

- CUTD TRACK STRUCTURE/NOISE TEST SECTIONS (GRANT

TUNNELING

- WMATA CHEMICAL GROUT TEST SECTION (GRANT)
- WMATA MUCK UTILIZATION GUIDELINES (GRANT)
- MTA-MD COMPACTION GROUT TEST SECTION (GRANT)
- MTA-MD PRECAST CONCRETE TUNNEL LINERS (2 GRANTS)
- MARTA TUNNEL SUPPORT SYSTEM TEST SECTION (GRANT)
- MBTA SITE EXPLORATION DEMO (TSC CONTRACT)
- MBTA TUNNEL BLASTING DEMO (TSC CONTRACT)

John F. Hoban, Director
Rail Transportation Department
Vice President & General Manager PATH

My role as anchorman on this panel is to provide the transit industry's view of UMTA's R&D program -- where we came from, where we are today, and the opportunities in the future. As an introductory note, let me express a very personal satisfaction with the cooperation that the industry has been getting from George Pastor. But if there is a flaw in our relationship, I think it could be analogized to Church -- that is the problem of putting Sunday's good intentions into practice the other days of the week.

With the reawakening of interest in mass transit during the mid 1960's, and the formalization of that interest in UMTA's R&D program,many people believed that the multiple new technologies that had sent objects and man to and from outer space with mind boggling precision need only be unleashed on the mass transit problem and the whole situation would be solved. Needless to say, this nirvana proved illusory.

Perhaps, as an industry, transit and its management are conservative. They are concerned with reliability, maintainability, safety and the need to move large numbers of people in the most economical manner. Transit has a lot of in-place technology that works. This is not to say it cannot work better, but on balance, the new must be proven to be better than the old by a series of important criteria.

The transit industry must be concerned with development in contrast to pure research. Promising ideas must be field tested, modified, and evaluated before they can be broadly applied in actual and everyday service. As a manager, the risks of premature imposition of unproven technology is simply too great. The casualties of the "technical fix" syndrome are many. It was for this purpose that the industry at substantial cost to itself, created the Transit Development Corporation some six years ago to bridge this gap between research and practical use. Unfortunately, it never worked out to the full degree originally intended.

Today the emphasis within the transit industry still is on development. While research is vital, the systems that are currently being planned and constructed with existing technology will be serving the public for the next 50 to 100 years. Therefore, the development and delivery of cost effective technology focused on the current capital and operating needs of transit industry should be a high priority joint effort. As a step in this direction, I strongly urge that UMTA staff become working members of APTA technical committees so that they, and we, can become more effective cooperators in providing efficient mass transit services.

It should be recognized that many of the barriers to the application of cost effective solutions are institutional as well as technological. For example, bids were recently received by the Federal Rail Administration for new escalators at Penn Station, Newark. The cost for each escalator was $140,000 compared to actual bid price of $75,000 only two years ago. While inflation has had some impact on the bid price, I believe that stringent provisions of the contract were responsible for most of the increase for these escalators were in no way unique. While contractual protections are comforting, we must carefully examine contract boilerplate, bolt by bolt, to assure ourselves that the protections provided truly justify the increased cost that results.

Further, any large scale enterprise must have a certain amount of bureaucracy. But the mini bureaucracies, both internally within our organizations and within governmental agencies, -- magnifying each procedural step -- have also become barriers to cost effectiveness by losing sight of what the procedures are supposed to achieve. In Buffalo it was necessary to revise their Environmental Impact Statement eleven times. This is a victory of process over progress. The problem is that we often overlook the obvious goal of providing the best possible transportation service to the public at the least possible cost and instead become over-involved in microscopic reinterpretations of rules and regulations. I recommend that both the industry and the government work hard to gain a mutual awareness of and respect for the contribution each has to offer in the achievement of our common objective. This is a fertile area for research.

Another area in which there is opportunity for cost effectiveness is in the evaluation of system life cycles. The artificial separation of R&D programs, capital grant programs and operating assistance programs is not a reflection of the real world of public transportation. As a manager, I must be concerned with optimizing all of these in terms of the bottom line result. Depending on interest rates, $1 in operating costs is equivalent to more than $10 in capital funds. Therefore, an integrated system life cycle approach which evaluates development, capital and operating costs over the life of a system can result in lower overall cost. Compartmentalization of programs, indeed almost fragmentation, can only lead to a less than optimum result.

There are other areas for realizing efficiencies and economies in developing mass transit facilities.

The design stage, although accounting for only a small percentage of the entire project cost, has a significant effect on the final price tag. This is where time should be spent in attempting to achieve the most economical design. Operators are often faced with subsequent high cost because of a designer's inflexibility. One solution of this problem is to involve the contractors in the design phase. By creating constructive conflict, the owner's attention can be focused on areas where real and substantial cost savings are possible without any real impact on utility. An effective tool in this process is the value engineering concept which provides bonuses for cost saving ideas.

Another technique is to make the designer fully aware of the amount budgeted for the cost of his piece of work. (i.e., "build to cost"). Too often we set the designer to work and he creates the perfect design without consideration of cost.

Inflation contributes significantly to increased project cost when delays occur or when, as today, economic conditions change markedly. This risk affects operators, contractors, federal fund requirements and ultimately, users. No single party should bear the entire burden of this risk. If, for instance, operators as a collective group absorbed inflation costs, there would be very little pressure on contractors to bargain hard on labor contracts or equipment or materials purchases. Yet contractors should not be required to absorb the entire burden of inflation, since they do not have full control over it. In addition, the operator does not want a contractor to insert high contingencies in his bid to cover potential and unanticipated inflationary impacts.

Another institutional consideration is the goal to achieve social objectives such as access to the elderly and handicapped or the award of contracts to minority business enterprises. The industry does not question the validity of the social objectives. It does question, however, if the burdens placed on the industry -- financially and operationally -- truly reflect a prudent balance in terms of the downstream results.

In summary, I think our goals are common ones -- that is to offer the most cost-effective mass transit service that we can. Technology research and development is one part of the mosaic. However, I feel that some formal R&D effort should be conducted of the costs that we impose upon ourselves through arbitrary procedures and processes that serve but limited purposes. Let's direct some of our time and talents to researching these areas.